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TITLE

A STUDY OF LOGGING SLASH IN RELATION TO IPS BREEDING

Progress Report - Season of 1949

by

George R. Struble

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August 7, 1950

To: D. E. Parker, Acting in Charge, Forest Insect Investigations
Beltsville, Maryland

From: F. P. Keen, Entomologist in Charge, Berkeley Laboratory

Subject: Struble's report "A Study of Logging Slash in Relation to Ips Breeding"

Enclosed is a progress report by Struble covering the results of last season's study of Ips behavior and epidemic development. Struble has concentrated his attention on the biological factors which make for heavy or light populations. This last year he followed results on four areas to see whether large populations developed epidemics in standing trees. They failed to in one case where populations were heaviest. This confirms previous observations that population alone is not the answer to the Ips problem. Tree condition and other factors appear to be more important.

The present report is in no way conclusive but simply adds another chapter to the evidence being accumulated on Ips behavior, and possibilities of effective control.

This year Struble is studying the effect of temperature on adult behavior, for after all it is the adult which decides whether he wants to attack a living tree or not. We hope this study will reveal some previously unsuspected tendencies.

cc: Furniss
Evenden
Regional Office
Sierra N. F.

Enclosure

A STUDY OF LOGGING SLASH IN RELATION TO IPS BREEDING

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By

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July 1, 1950

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INTRODUCTION

Fresh ponderosa pine slash in California's pine areas is the principal breeding medium of the five-spined engraver beetle Ips confusus Lec. Intensive recent studies in the Sierras have shown that slash or debris created by logging or other clearing operations during spring and summer is attacked more heavily than at other seasons. Prolific broods result, and large adult populations emerge by mid-summer. These adults often make aggressive attacks on living trees in the vicinity of the slash, with the result that many are killed by late summer and fall. This tendency is especially associated with an early seasonal sporadic or "shot gun" type of cutting, but has been found to occur at times in the vicinity of year-long cutting operations. Often, even though slash is abundant, and heavy adult populations are reared by mid-summer, no attacks occur in the reserve stands. Sometimes outbreaks are found in stands remote from logging slash areas.

The conditions or factors which influence mid-summer and fall attacks in living trees are not very well understood. For this reason many attempts have been made to secure information basic to practices intended to prevent losses, especially to find out when and where an outbreak is apt to occur. One means of study was to establish case histories representing separate operations at different times during several seasons of logging activity. Between 1945 and 1948 some 29 records were taken, involving approximately 14,000 acres of logging slash, most of them in western Mariposa and Madera counties. The principal points considered were cutting schedule, Ips attack and development period, estimate of populations per unit of bark area, and subsequent killing in reserve stands. These records fell short of providing the answers to why attacks were abundant in living trees at one time and not at another.

The reasons appeared to stem from a lack of detailed information on a number of factors which may have influenced the behavior of Ips locally in the areas studied. Consequently, in 1949 it was decided to make more intensive studies of a limited number of slash areas, considering especially; (1) the origin or source of infestation; (2) the quantity and character of fresh slash as a breeding medium; (3) the climatic factors influencing development; and (4) stand resistance.

This study was undertaken between June 20 and October 1, with final examinations on November 29. The cutting areas selected were located on the Sierra National Forest in the vicinity of Miami Field Base in Mariposa County. Assistance on this project was rendered by Douglas F. Parker, Field Aid (SP-5), graduate in Zoology at the University of California.

PROCEDURE

Selection of areas

The choice of study areas was limited by greatly curtailed logging activity compared with that of previous years. Four selections were made in privately-owned timber where current seasonal operations in ponderosa pine were in progress. These were designated Lower Sonny Meadow, Higgins, Footman Ridge, and Keyfavor. The slash in all areas consisted of unlopped tops. Principal variations between areas were in size, character and percent of stand cut, site, and elevation.

Records

The size of each irregularly-shaped cutting area was estimated. Each top or log capable of supporting broods was measured for determination of bark surface. This was done by securing basal diameters and length to a 4-inch diameter of all tops capable of supporting broods. The bark surface was determined by the formula: $S = \frac{h(\pi D_1 + \pi D_2)}{24}$.

Probable infestation sources (slash or standing trees containing overwintered adults) were located. Estimates were made of emerging populations from these sources, based on emergence from caged samples. Approximate distances from infesting sources to fresh slash were recorded.

Frequent field examinations were made to secure data on attacks and brood development in the fresh slash. Emergence and population data were based on rearing records (Table 2) from 5 selected sample log sections representing each slash area. Each log containing 3 square feet of bark surface was placed in a separate rearing cage as soon as broods reached maturity. This information on emergence was used in calculating the populations within a given slash area.

Climatic data

No specific climatic records were kept locally in any of the areas studied. However, precipitation and temperature data were secured from stations generally representative of those to be found in the areas.

Condition of Reserve Stand

Stand vigor was judged by the general character of the crowns of reserve trees. In general, there was little difference indicated in the different areas studied. Differences, if any, resulting from possible variations in soil moisture, were not reflected in terms of visible crown differences.

Top-bole phloem moisture

Possible seasonal variations in top-bole phloem moisture were secured by means of arch punch samples taken each 20 days during a 60-day period late in the season. Five 1-1/4 inch cylinders of phloem were secured each time, and the phloem moisture determined in percent of dry weight. The samples were dried in an oven at 100°C.

RESULTS OBTAINED

Comparison of Slash Factors and Breeding

The principal elements with respect to Ips breeding, and indicated to have the greatest influence on the production of killing adult populations, are compared in Table 1. The only factors having a significant bearing on the production in a given area were type of cutting, number of tops, and amount of favorable breeding surface. In other words, the areas which were most heavily cut, thus providing more tops and favorable breeding surface, were the ones which produced the heaviest broods. To a limited degree, as shown by the production of adults in the Keyfavor slash, the number of parent adults as indicated by intensity of attacks, was also evidently a factor. The factors of elevation, site quality, size of cutting areas, source of infestation, and type of stand were not significant in this comparison.

While no information was secured on the quality of slash material in the different areas studied, and production of mature broods, this factor is indicated as important. The highest production per square foot of bark surface, for example, occurred in the Footman Ridge slash, and lowest in the Higgins and Keyfavor slash. These differences are attributed in part to variations in nutritional elements or some other quality of phloem.

Table 1. Comparison of Key Factors in Slash Areas Studied

Factors	Slash Area			
	Lower Sonny Meadow	Higgins	Footman Ridge	Kayfavor
Physiographic				
Elevation	4,500	4,500	4,500	2,800
Site	I	I	II	III
Source of infestation				
Distance (miles)	1/4	1	1/8	1/2
Number Ips adults [1/]	100,000	150,000	1,200,000	300,000
The cutting area				
Acres	15	10	15	2-1/2
Type of stand	Second growth	Virgin	Virgin	Second growth
Cutting schedule	5/26-6/1/49	6/20-30/49	6/1-10/49	6/15/49
Type of cut	Light selective	Light select	Clear	60% selective
Slash character				
No. tops (unlopped)	50	40	250	15
Favorable breeding surface (sq. ft.) [2/]	2,700	4,400	20,000	1,100
Ips Attacks and breeding				
Attack period	6/5-20/49	7/5-15/49	6/15-25/49	6/25-7/5/49
Attacks/sq. ft. [3/]	6	6	9	20
Adults emerged/sq. ft. [3/]	120	92	202	98
Adults emerged in slash area [4/]	300,000	400,000	4,000,000	100,000
Peak emergence period	7/29-8/4/49	8/20-9/15/49	8/1-15/49	7/28-8/4/49

1/ Estimates based on emergence data from representative 3 square-foot infested log sections of source material.

2/ Based on measurements of all tops favorable to brood production in a given area which included basal diameter and length to 4-inch diameter. Bark surface formula used: $S = \frac{h(\pi D_1 + \pi D_2)}{24}$

3/ Based on emergence data from 5 representative 3-square-foot infested sections from each study area (Table 2).

4/ Based on emergence data and calculated bark surface in each study area.

Effect of Emergence on Reserve Stands

The attack periods of emerging beetles are indicated by peak emergence as shown by Table 2. In the Sonny Meadow areas (Lower Sonny Meadow and Higgins) this period occurred for 6 weeks beginning August 1; at Footman Ridge for 3 weeks beginning August 15, and at the Keyfavor area for 2 weeks beginning July 25. Except at Footman Ridge each area was free from fresh slash and hence reserve stands were subject to attacks by the beetles reared there. The slash adjoining the study areas in the Footman Ridge area may have absorbed some of the population reared there.

No evident attacks or subsequent kill by beetles from this emergence occurred, however, in any of the areas studied. This was somewhat surprising in the Footman Ridge area where so many adults were reared, but it was also evident that many were absorbed by fresh slash. The populations released in the other areas were evidently dispersed at points remote from where reared, or were lost.

It is to be noted that there was a subsequent kill in the Footman Ridge area which showed up by November 29, and consisted of 19 medium and small sugar pines and ponderosa pines. This kill could not, however, conceiveably have stemmed from the August emergence, inasmuch as fades from that source would have been in evidence early in October. Rather, it is presumed to have originated from beetles emerging in October from slash adjacent to the study area which may have absorbed the August flight of beetles. This was due probably to an unusually long, mild October and November period which permitted the flight and establishment of another generation at a time when the reserve stand was fully dormant and susceptible to attacks.

Table 2. Emergence From Samples Representing Each Slash Area in 1949

Area	Sample Number	Adults Total	Emerged Per Sq. Ft.	Period of Emergence: Date: Begin	Peak	End	Days
Lower Sonny Meadow (Elev. 4500)	1	380	127	7/14	7/29	8/24	41
	2	312	104	7/14	7/30	8/26	43
	3	396	132	7/15	7/31	9/6	54
	4	396	132	7/14	8/1	9/4	53
	5	322	107	7/15	8/4	9/3	49
	Total	1,806	Av. 120			Av.	48
Higgins (Elev. 4500)	1	267	89	8/2	8/20	9/27	56
	2	88	29	8/13	9/15	9/21	42
	3	369	123	8/13	9/4	9/27	49
	4	384	128	8/12	9/13	9/29	51
	Total	1,108	Av. 92			Av.	49
Footman Ridge (Elev. 4500)	1	266	89	7/13	8/15	9/5	53
	2	475	158	7/8	8/4	9/5	58
	3	920	307	7/7	8/1	8/20	41
	4	466	155	7/7	8/2	8/24	45
	5	914	304	7/7	8/3	9/1	52
	Total	3,041	Av. 202			Av.	50
Keyfavor (Elev. 2800)	1	633	211	7/22	8/1	8/30	39
	2	370	123	7/22	7/30	9/2	42
	3	131	44	7/22	7/28	8/18	28
	4	193	64	7/23	8/4	9/3	42
	5	141	47	7/25	8/2	8/26	32
	Total	1,468	Av. 98			Av.	36

Probable Reasons for no Attacks

Precipitation data from 4 stations in the general vicinity of these slash areas showed similar amounts, varying from 29 to 34 inches. In all cases, during the spring period, there was a complete deficiency in April followed by moderate precipitation amounts in May.

Measurements secured of top-bole phloem moisture during July and August from selected trees representing each area showed: (1) no significant losses in moisture in any of the areas for the 60-day period; and (2) slight gains in phloem moisture in half of the trees in two of the areas.

Maximum temperatures in all except the Keyfavor area ranged from 70 to 82°F with an average diurnal spread between maximum and minimum temperatures of 22° during the emergence and flight period. In the Keyfavor area the maximum temperatures were 5 to 10° higher.

These data tend to show that the stands in the 4 study areas were not suffering from moisture deficiencies at the time of Ips flights. The precipitation and summer temperatures both are presumed favorable to the maintenance of good stand resistance, and this may have repelled attempted attacks, even under the conditions at Footman Ridge where Ips populations were overwhelming in comparison with the numbers in the other areas.

The effects of these climatic factors could well have changed within a month to 6 weeks later, resulting in less resistance and successful invasions. It is probable that this very situation occurred in the Footman Ridge area where the November killing was found.

NEED FOR FURTHER STUDIES

This study represents one more example of an attempt to find an answer to an extremely complicated question. It emphasizes the need for

greater detail in planning, the execution of which is both time-consuming and costly. It constitutes proof that the answer cannot result alone from studies and records under field conditions, but in addition, will require considerable experimentation under carefully controlled conditions.

The complexity of factors involved are more than entomological. An accurate understanding depends on the principal processes involved in an interrelationship between the insect and its environment, of not only the biology and habits of the insect and its enemies, but also knowledge of the host, and fungus and/or bacterial organisms affecting both the insect and the host. Detailed information is needed on the physiological elements involved in host susceptibility; of the insect nutritional requirements.

The accomplishment of the details necessary to secure the much desired answer is dependent on the combined and coordinated efforts of the entomologist, physiologist, and pathologist. This is true not only of studies involving Ips, but also with all of the tree-killing bark-beetles, best known of which are the western pine beetle and mountain pine beetle. Such studies are fundamental, with similar principles applicable to all species.

SUMMARY

Studies were continued from 1946-1948 in the Sierras on the relation between ponderosa pine slash and Ips outbreaks. Biological and host studies, and many case histories served to point out the complexity of factors which determine infestation patterns. Thus, at the beginning of 1949 the questions as to when, where, or under what conditions Ips outbreaks occurred were still largely unanswered. In planning for the 1949 seasonal studies emphasis was given to detailed records pertaining to local slash areas in relation to subsequent infestations in reserve stands. The points con-

sidered were: (1) the origin or source of infestation, (2) the quantity and character of fresh slash as a breeding medium, (3) the climatic factors influencing development, (4) stand resistance. Four separate current slash areas were studied in detail. The proximity of infestation sources varied from 1/8 to 1 mile in the different areas studied.

The results obtained from the detailed study of the 4 slash areas revealed the following points:

1. The total number of mature brood produced related directly to the amount of favorable breeding surface in a given area.

2. The factors of elevation, site quality, size of cutting area, source of infestation, and type of stand were not significant to the amount of brood produced in slash or subsequent attacks on living trees.

3. Attack intensity in slash around 20 per square foot, as occurred in the Keyfavor area, is indicated as having a significant effect on brood production because of overcrowding by parent adults and subsequent feeding space per larva.

4. The higher brood produced in Footman Ridge slash may have resulted from certain qualities of this slash locally which was favorable to breeding.

5. Despite very heavy populations of adults emerging in one of the areas (4,000,000 at Footman Ridge) there were no subsequent attacks in reserve stands. Reserve stands in the vicinity of the other slash area studies were likewise unattacked.

6. Limited information on climatic data and tree-growing conditions indicated that stands in the 4 study areas were not suffering from moisture deficiencies during the August flight and attack periods, and this is cited as a reason for no killing attacks at that time.

7. This study serves to point out the need for greater detail in research planning under carefully controlled conditions, and the coordinated effort required by the scientific fields involved in bark-beetle infestation cycles.

Photo #1 (13381-A). Footman Ridge Slash Area. About 80 percent of virgin stand cut with slash accumulations consisting mainly of unlopped tops, proved to be an ideal breeding area for Ips. Tops of ponderosa pine and sugar pine in foreground.

Photo #2 (13382). Keyfavor Slash Area. Long unlopped tops of limby ponderosa pine were heavily attacked by Ips, but broods were moderate.